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FOREST INSECT
PROBLEMS
of the
YOSEMITE
NATIONAL PARK

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FOREST INSECT PROBLEMS

of the

YOSEMITE NATIONAL PARK

Prepared by the Division of Forest Insects,
U. S. Bureau of Entomology and Plant Quarantine,
in Cooperation with
The Field Division of Forestry, National Park Service,
Berkeley, California
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FOREWORD

This paper has been prepared by J. E. Patterson, of the Division of Forest Insect Investigations, Bureau of Entomology and Plant Quarantine, United States Department of Agriculture. It is one of a proposed series of manuals dealing with the forest insects, and related problems of their investigation and control in the western National Parks. Two manuals of this series have already appeared. These are: "Forest Insect Problems in Sequoia National Park," and "Forest Insects of the California National Parks, Part I - Insects Affecting Sugar and Ponderosa Pine." Both of these manuals were prepared by Donald DeLeon of the Field Division of Forestry, National Park Service. The present paper is intended to supplement these first manuals; particularly by an account of the past forest insect depredations in the Yosemite National Park, and the efforts that have been made in combatting them. It also records the story of forest entomology in this Park, which is of especial interest because of its inception in the early history of Forest Entomology in the Western United States.

The information given here, has for the most part been abstracted from reports and memoranda in the files of the Office of the Division of Forest Insect Investigations, Berkeley, California, and in the Office of the Superintendent, Yosemite National Park. Much of the information, however, has been supplied by J. M. Miller from his personal knowledge gained through years of intimate contact with the insect problems of this Park. Some of the information is original and was gained through the author's early connection with these problems.

Berkeley, California
December 1, 1935

FOREST INSECT PROBLEMS

of the

YOSEMITE NATIONAL PARK

INTRODUCTION AND EARLY HISTORY

The forests of the Yosemite National Park present a visible record of the role which insects play in bringing about profound changes in the tree cover of park and recreational areas. Dead forests of lodgepole pine, showing on the bleached sapwood the scribing of tiny, tree-killing barkbeetles, cover some thousands of acres in the upper regions of this Park. These so-called "ghost" forests, nature's own record of old barkbeetle invasions, have stood for decades and many of the deadened trees will stand for years to come. On the floor of the valley is still standing the skeleton of a giant ponderosa pine, the largest specimen of its kind in the Sierras. This veteran of a thousand storms finally succumbed to the attack of the western pine beetle in 1932.

The story of what has been done in the Yosemite to study the manner in which insects accomplish the killing of trees and devastate entire forests is an important phase of the early history of Forest Entomology in the western United States.

It was during the period while the Park was administered by the United States Army that the insect investigations in this region were first brought to the attention of the newly created Division of Forest Insect Investigations of the Department of Agriculture.

The earliest recorded observations to appear in the official files, were contained in a letter written by Ranger Charles Leidig in 1903 to the Secretary of the Interior. It reported the widespread death of lodgepole pine which was ascribed generally to a leaf-mining moth.

Dr. A. D. Hopkins, known as the father of forest entomology in North America, and the first chief of the Division of Forest Insects, visited the park in 1904. He examined trees on the valley floor, along the old Wawona Road, and at Glacier Point. He found infested ponderosa pine and sugar pine at these places. Some interesting historical photographs of beetle killed trees were made by him at Chinquapin and at Alder Creek and were published on pages 47, 86, and 89, in his manual of tree killing beetles, "The Genus Dendroctonus."

The needleminer attracted the attention of one of the leading entomologists of the country, J. H. Comstock, who made a trip

through this region in 1907, and reported its presence to the U. S. Bureau of Entomology. Professor Comstock wrote in this letter:

"While in the high Sierras this summer, I saw large areas of dead tamarack pines (lodgepole pine) and many trees adjoining these areas that were dying. The dying trees were infested by a leaf-mining Tineid whose habits resemble those of Gelechia pinifoliella. The injuries of this Tineid are so extensive that I am inclined to believe that it is the cause of the death of the pines."

Other entomologists who have been closely identified with insect conditions in the park are: Dr. H. E. Burke, who made his first visit in 1906, when he investigated conditions in and about the valley and at Tenaya Lake and in the Tuolumne Meadows; and Dr. E. P. Meinecke, forest pathologist, who surveyed the lodgepole pine regions in 1911, and wrote one of the early accounts of the needle-miner in these areas.

Later, in 1912, Mr. J. M. Miller made extensive examinations of insect conditions throughout the park forests, and it was largely upon his recommendations that the first beetle control work was undertaken in 1913. Mr. Miller also investigated the needleminer which was widespread throughout the Tenaya and Cathedral Creek watersheds at that time.

J. E. Patterson was first connected with the insect problems of the park in 1917, when he was detailed to make a study of the life history of the needleminer, and to make a general survey of the barkbeetle status. He has been intermittently associated with these insect problems since that time.

In late years many other entomologists have visited the Park, notably Dr. F. C. Craighead, the present Chief of the Division of Forest Insects.

Man's attempt to control these destructive insects, and to minimize the loss of desirable park trees, began in 1912 while the Army was still charged with the administration of the Park. Control operations were attempted in the lodgepole forests at Lake Tenaya and were extended during the succeeding three years to other infested areas. These early attempts were inadequate in the lodgepole pine forests, as funds were available to cover only part of the infested territory, and the barkbeetles from untreated stands soon invaded the areas that had been cleaned by control work.

In 1914 administration was transferred to the Interior Department and a civilian superintendent placed in charge. Superintendent W. B. Lewis continued insect control work in the pine stands in

the Yosemite Valley, at Big Meadows and along the Wawona Road, during the decade from 1916 to 1924.

It was not, however, until recent years that a comprehensive insect control plan was established, and annual inspections of all of the park forests have been undertaken. These inspections have been followed by control work wherever such measures were warranted. Under the regime of Colonel C. G. Thomson, the present Superintendent, the control of insect epidemics has become one of the major forest protection activities in this Park. Several large insect control projects have been undertaken and successfully completed in the ponderosa-sugar pine type forests. These recent projects have been extended to include the floor and surrounding areas of the valley, the scenic strip along the Wawona Road, the Wawona Basin, Mariposa Grove of Big Trees, Big Meadows, and the recent Rockefeller acquisition. The resulting clean forest on the principal recreational areas attest the successful application of this plan.

DEAD FORESTS - AN EXAMPLE OF FOREST INSECT DEPREDACTIONS

Many visitors to the High Sierras of the Park have noticed and commented upon the amount of dead timber resulting from past insect depredations, and a few have written of the things which they saw. One of these published articles was written by a well-known author, J. Smeaton Chase, and appears in his book "Yosemite Trails", published in 1911. On page 74 he writes:

"There is a melancholy amount of dead timber throughout this region. Long stretches of tamarack forests have perished as if at a stroke. Close examination shows that they have been destroyed by fire, although the polished skeletons would seem to indicate almost any other agency."

This paragraph undoubtedly had reference to the dead forest above Lake Tenaya, since Chase passed through this stand and his description of this part of the trip contained the above notation. Chase, in common with many other visitors to these regions, thought that these "ghost" forests were caused by fire. However, the absence of fire scorching and the presence, even at this late date, of the prominent scorings of the mountain pine beetle brood galleries deeply engraved on the bleached surface of these dead and naked trees are indisputable evidence that they were killed by insects.

Dead forest existed in the northeastern section of the Tuolumne watershed when the Yosemite areas were first set aside as a National Park. Although the origin of these old infestations is obscured through lack of definite records, it is evident from the observations made by the men who first took over the protection

of the Yosemite as a National Park, that insects had even then left a conspicuous record of their activity in the lodgepole forests. During the early "nineties", when the civilian rangers were driving trespassing Basque shepherders and their flocks out of the sub-alpine meadows of the back country, their interest was aroused in the occurrence of dead forests and in the activities of certain insects which they observed in these areas.

Archie Leonard, one of these pioneer rangers during the days of the Army regime, wrote of his observations in a letter in 1907 to J. M. Miller, as follows:

"Some years ago I saw many dead trees in Jack Main Canyon and other places in the high country. Some summers there is a little white fly which comes out of the needles by the millions. These fly for several weeks around the trees. After this flight the tamarack trees look sickly and many needles fall. Then a small bark borer drills into the bark, the pitch runs out in spots, and the trees die."

The "white fly" observed by Leonard was undoubtedly the lodgepole needleminer, and the borer the mountain pine beetle which followed the defoliation of trees by the needleminer through the Tuolumne watershed.

How the Lodgepole Forests have been Killed:

The dead lodgepole forests of the park have been the battle ground where a struggle was waged between primitive forces. On the one hand was the natural resistance of the trees to the attack of insects, and on the other hand the potential power of these enemies of the trees to overcome such resistance. The barkbeetles, the most destructive of the insects, are by sheer force of numbers capable of overcoming and killing the hardiest trees. During periods when the beetle population is high, widespread destruction of forests result from their united attacks. One such period occurred between the years 1910 and 1920, when the lodgepole forests of the upper Tuolumne watershed were swept by successive generations of the mountain pine beetle, and almost complete killing of these magnificent stands resulted.

In this, as in many other instances, the conquest of the beetles was made easy by the needleminer which had previously defoliated the trees and thereby impaired their natural resistance so that fewer beetles were necessary to overcome the individual trees. This condition permitted the beetle population to successfully establish new broods each year over an increasingly greater territory. This needleminer-beetle association has been common in the lodgepole forests of the Yosemite and the history of the Tuolumne stands has been paralleled by that of other lodgepole forests of the upper park country. The early epidemic which occurred about

1890 resulted in a dead forest in Jack Main and Matterhorn Canyons prior to the turn of the century, and the "ghost" forest at Lake Tenaya is a more recent example.

The transition from a healthy and beautiful lodgepole forest to a stand of ghost trees can be a sudden affair. In 1916, the needleminer had become firmly established in Snow Flat on the Tioga Road. Defoliation was very severe and many trees were entirely stripped of mature needles, so that the entire stand presented an appearance of a larch forest in late fall. The mountain pine beetle invaded this defoliated stand in 1917 and by 1922 there was scarcely a living mature lodgepole left outside those on the open meadow sites.

There is a marked periodicity in the epidemics of this needleminer. It undoubtedly occurred just before 1900. It again appeared in 1911 at Lake Tenaya, Cathedral Creek, and in the Tuolumne Meadows, and continued unabated until 1921, when it suddenly subsided. It reappeared in 1931 and 1933 at Porcupine Flat and on the divide back of Clouds Rest. The present intensity of the infestation at these places is indicative of another epidemic period. The known cycles indicate periods of 10 years duration in epidemic form and an equal number of years when the infestation is quiescent. It may be regularly recurrent on this schedule, and if so, it will be epidemic until about 1943.

There has been a close correlation between the activities of the needleminer and those of the mountain pine beetle. In general, their epidemics have been coexistent; the barkbeetle closely following initial defoliations by the needleminer.

The complexity of the association between these two insects has never been fully worked out, though anyone who has visited the scene of action is made strikingly aware of the results. It is, however, an historical fact that the killing of the park lodgepole forests by the mountain pine beetle was in almost every known case preceded by defoliations of the needleminer. The few exceptions are certain isolated areas like Peregoy Meadows. Because of this known order of events, entomologists generally concede the primary importance of the needleminer.

A combination of these two insects is not essential, however, to successful attack and death of the trees. Each one working separately is capable of devastating forest areas. Defoliation by the needleminer has resulted in the death of lodgepole pine in areas where the barkbeetle was not present. Such examples are found on upper Murphy Creek, in Glen Aulin, and around Dog Lake. It was formerly thought that the needleminer damage did not directly result in the death of defoliated trees. The author, in common with others, held this opinion for several years, but more recent investigations have shown the error of this assumption. The mountain pine beetle ravages

throughout these defoliated stands have complicated the picture and have largely obscured the primary result of needleminer defoliation. Examinations in the very few defoliated areas where the beetle has not been present in sufficient numbers to cause noticeable damage reveal many dead trees that had been attacked only by the needleminer. J. M. Miller found by actual count that this number ranged between 8% and 12% of the total dead trees, even in stands where the beetle infestation had been epidemic. In central Oregon the same, or a closely related species, has killed lodgepole pine trees over quite extensive areas, and without the aid of any other agent. Likewise, sufficient evidence of the destructiveness of the mountain pine beetle is furnished by infestations in this park at Perejoy Meadows and on Bridal Veil Creek, areas where the needleminer has never been epidemic; and also by destructive outbreaks in other western forests. Notable among these last is the recent epidemic in the Crater Lake National Park which threatened the entire forest, killing trees that had not previously been attacked by any other insects.

Features of the Dead Lodgepole Forests:

There are many "ghost" forests in the park. The term is appropriate since the naked and bleached skeletons of the standing dead trees present a weird and vivid spectacle. The best examples are at Lake Tenaya; in Jack Main, Matterhorn, and Stubblefield Canyons; in Smoky Jack Meadow; and on Cathedral Creek. The fact that most of these dead trees are still standing 25 or 30 years after they were killed is most remarkable and has been the source of speculation. Dr. Donald DeLeon believes that this persistence in the normal upright position for so unusual a period is due chiefly to two causes. First, the killing was so extensive and rapid that wood-boring insects, which ordinarily honeycomb the basal trunks, were not present in numbers sufficient to infest the multitude of dying trees; and second, the drying out of the trunks was so rapid that fungi were unable to develop and weaken the lower stems.

To the great majority of people, these dead forests are scars on an otherwise perfect landscape. To a lesser number they are an interesting manifestation of nature in violent mood and afford a contrast which may be enjoyable to those individuals who find monotony in a continuous green canopy. Because of the absence of shade from green tree crowns there is a wealth of wild flowers and alpine shrubs, which are only sparingly found in the living forests. Animal life too may be seen to better advantage. These features make these areas interesting places to explore. In time young trees spring up and form dense stands of young growth in these deadened areas. Usually lodgepole pine is the species which forms this new forest, but on northern exposures and the better sites, fir and hemlock may compose a considerable percent of the stand which eventually will replace the dead forest.

In contrast to the wholesale destruction in the lodgepole forests of the upper park, the beetle losses in the ponderosa-sugar pine stands of the lower regions of the park have been less extensive. These latter losses occur as single trees or in scattered groups of from 2 to 20 trees, and while they are less spectacular than in the lodgepole pine stands, they are to be regretted since many of the killed trees are the largest specimens in the forest, and many occur in the road screen, in the campgrounds, and in the principal recreational areas. Examples of such losses are the giant yellow pine on the Valley floor, and others in the Mariposa Grove where sugar pines of great size and age have been killed.

CONTROL OF FOREST INSECTS IN YOSEMITE

The protection of forests for the purpose of realizing their greatest benefit as cover on recreational and scenic areas, in this as in other National Parks, is a function of the Park Service. The insect control policy as approved by the Director of the National Park Service, is defined on pages 22-26 of the Manual of the Branch of Forestry and is the basis upon which plans and programs for this work are formulated.

To the National Park Officers, who are directly charged with the responsibility of conducting forest insect control work as a phase of this protection, some knowledge of the more important insects and their behavior is essential. However, it is not the purpose of this paper to present the information which will aid in the determination of the more important forest insects, or to detail the methods used for controlling them. Some excellent publications are available for this purpose, notably California State Bulletin #7, "Insect Enemies of California Pines and their Control," by F. P. Keen, "Insects of Western North America," by E. O. Essig, and recent mimeographed publications issued by the Field Division of the Branch of Forestry of the National Park Service.

Types of Infestations:

Each species of forest tree has its particular insect enemies, and insects, as a rule are discriminating in their attacks. This habit of selection is a definite characteristic of barkbeetles. The western pine beetle in this park will attack no tree except ponderosa pine. The mountain pine beetle is found on lodgepole pine, sugar pine, and ponderosa pine, but when an epidemic infestation develops in an area of mixed stand, one tree is usually the preferred host and the others are attacked only incidentally.

These selective habits of barkbeetles and other insects make the protection of forest areas against their depredations an entirely different problem from that of protection against fire. When a fire develops, it attacks all species of tree growth indiscriminately. The only effective strategy of control is to corral the fire within the smallest space possible and prevent further spread. Insect infesta-

tions, on the other hand, may run through a mixed stand and destroy only one tree species, leaving the other species uninjured. The need for control, therefore, can be gauged by the values of the species that are being killed and the ultimate effect of an epidemic on the composition of the stand.

In the Yosemite, the more important forest insect infestations involve about 8 primary species of insects and 7 species of coniferous trees. With the many combinations that are possible among these insects and their host trees, control work becomes a fairly complicated and technical undertaking. Both the methods of control that are to be used and the strategy of their application depend upon the particular species of insect that is to be destroyed, and the host tree that is threatened. The forester whose duty it is to protect forest values should be able to recognize the significance of each particular type of infestation. As an aid to a better understanding of the control problems that have developed in the past and that are to be expected in the future, it is well to differentiate the Yosemite infestations into types.

Mountain pine beetle - sugar pine:

Mature sugar pines, particularly the large dominant trees, are the ones which are most commonly attacked by this insect, Dendroctonus monticolae. Frequently the killing of one of these great trees is a process that lasts for an entire season or longer. The attack may at first occur in the upper 25 or 30 feet of the bole, and an entire generation of beetles will develop in this part of the tree before the midbole becomes infested. The death of the tree will occur after a second or third attack has been made, when the infestation reaches the base. In other cases, when the beetle population is abundant the entire trunk may be heavily infested in the first attack, and the killing of the tree accomplished in a period of a week or two.

Large groups of trees are seldom killed in the sugar pine stands. The distribution of this type of infestation is usually in single isolated trees or in groups of two or three. These are spaced throughout the stand, their frequency depending largely on the intensity of the infestation.

Photographs by Dr. Hopkins in the Dendroctonus bulletin previously mentioned, show the type of loss which the Park sustained years ago from this type of infestation. Losses of varying degree have continued throughout the period since 1900, but the heaviest killing of sugar pine of which we have record occurred from 1930-33. During this period the mountain pine beetle became epidemic throughout the sugar pine belt along the western front of the park. Heavy losses occurred in the Mariposa Big Tree Grove and along the Wawona Road strip. On one section in the Alder Creek Basin approximately one million board feet of infested sugar pine were cut and treated during the control campaign in the spring of 1933. The trees treated

in this year included the largest tree yet recorded on any control project. This was a giant sugar pine cut and treated near Wawona. It measured 117 inches in diameter at the stump and 225 feet in height, and contained a volume of over 30,000 board feet. The Rockefeller Purchase area also became infested during the 1931-33 epidemic, but in much milder degree than the Wawona areas.

Since 1933 this type of infestation has been greatly reduced and at the present date (1935) no serious conditions are present. The belt along the entire western front should be closely watched in annual surveys, however, for any evidence of increase in these infestations.

Western pine beetle-- ponderosa pine:

Killing of ponderosa pine by the western pine beetle, Dendroctonus brevicornis, results from a rather sudden and concentrated attack of beetles upon the entire bole of the tree. Mature trees, particularly the slow growing ones, are preferred. When there is a small population of beetles, single isolated trees are taken, but when these insects are present in great numbers, trees are killed in large groups. As many as 100 trees of all age classes have been killed in an acre or two of forest land, where for some reason an unusual concentration of beetles has occurred.

Losses resulting from this type of infestation have always been of considerable importance in the Park. The western pine beetle has persistently taken a toll of the large mature trees on the floor of the valley. Many of the finest specimens of the trees which framed the vistas from scenic points have been lost in this way. Continual maintenance control work has held down the losses in recent years, but the ability of this insect to make fairly long flights has resulted in the trouble appearing in new areas or re-appearing in areas that had once been thoroughly cleaned. An example which illustrates the flight habits of this beetle occurred above the little Yosemite on the trail to Half Dome. There is here a small area of ponderosa pine surrounded by Jeffrey pine and completely isolated from the ponderosa type in other parts of the Park. When this area was cruised during the seasons of 1915 and 1916 for the Jeffrey pine beetle, no trace of western pine beetle infestation was found. Suddenly, in 1917, the beetle appeared in this isolated tract, and for several years thereafter small losses resulted annually from its attacks.

The heaviest timber losses which have occurred in the ponderosa pine stands developed during an epidemic of the western pine beetle which ran concurrently with that of the mountain pine beetle in sugar pine during 1930-33. The epidemic was prevalent throughout the lower elevations of the ponderosa pine type. Big Meadows and the Wawona Basin developed the heaviest centers with losses running as high as 150 trees, containing 250,000 board feet to the

square mile. The control work of 1933 was effective in breaking down this epidemic and losses have since been kept low by maintenance conducted largely by the CCC organization.

Jeffrey pine beetle - Jeffrey pine:

Around the rim of Yosemite Valley, Jeffrey pine is the predominating pine species. The primary enemy of this tree is the Jeffrey pine beetle, Dendroctonus jeffreyi. Its habits of attack are similar to those of the mountain pine beetle in sugar pine, except that the killing is nearly always accomplished by a first attack covering the entire bole. A large engraver beetle, Ips emarginatus, is often associated with the Jeffrey pine beetle in the attack on the main bole.

Group attacks may occur in the younger pine stands of Jeffrey pine, but the rule in the areas surrounding the Valley is the killing of single mature trees. Epidemic conditions comparable to the other two species of Dendroctonus in sugar pine and ponderosa pine have not occurred in the Park.

The areas where heaviest losses have occurred are in the Illilouette Basin and in Little Yosemite. During the seasons of 1933 and 1934, effective control work has been carried on in both of these areas by CCC stub camps.

Mountain pine beetle - lodgepole pine:

Outside of the needleminer areas, the most important enemy of lodgepole pine is the mountain pine beetle. In the southern Sierra type of this host tree, behavior of the infestation differs somewhat from that in the Crater Lake National Park where entire forests have been swept by great epidemics. The old mature type of lodgepole pine in the Sierras, where the stand is much broken by meadows, rocky formation, and fir type, does not appear to be susceptible to large epidemics unless the stands have been previously defoliated. Small group centers of infestation will form, however, in the stands bordering streams and meadows, and the mountain pine beetle population in these groups will persist year after year in the same locality and in about the same status. From 50 to 150 trees killed annually is near the limit of one of these small groups, but, in the course of time, a considerable amount of timber is destroyed.

One such group worked in the stream type along the Merced River in Little Yosemite for a period between 1920 and 1933. In the fall of 1933 this center was effectively cleaned up by a CCC stub camp. A similar areas of infestation ran for a considerable period at Perego Meadows. During the summer of 1934 a small grouping of mountain pine beetle was found in the lodgepole of the Illilouette Basin and control work was initiated by the CCC. A similar grouping was detected in 1934 on the recreational areas bordering

the Tuolumne Meadows. These groups were also cleaned by CCC control work. These CCC projects are the only ones which have been conducted for this type of infestation.

Needleminer - Mountain pine beetle - Lodgepole pine:

The characteristics of this type of infestation have been described in the section dealing with the dead forests.

The key to successful control in this type apparently depends upon development of a method of control for the needleminer, Recurvaria milleri. If the weakening of trees by defoliation can be prevented, the control of the mountain pine beetle within these stands can then be undertaken with some assurance of success.

In the lodgepole projects in Tenaya-Cathedral Creek in 1913-16, an attempt was made to check the beetle infestation only. It soon developed that this was impracticable so long as the needleminer remained active. The weakened defoliated trees showed no resistance to beetle attacks and, in a few years, the mountain pine beetle population coming in from outside areas built up into an infestation which completed the destruction of the forest.

In Virginia Canyon in 1914, control of the beetles was started after the needleminer had subsided in this area. This project was quite successful. The beetle population dropped back to an endemic condition after one season of control work, and it has shown no aggressive tendencies since then.

The first attempt to develop methods of controlling the needleminer were made in 1933 when the Bureau of Entomology and Plant Quarantine made some preliminary tests with oil sprays. Some of these gave considerable promise and in 1935 a fairly extensive control experiment was undertaken at Porcupine Flat. The use of this method is made possible by the fact that the moths of the needleminer lay their eggs during a short period in August of every other year. The larvae which develop do not migrate from tree to tree. Consequently a spray which will arrest the attack in its early stage will protect the tree for a period of two years. The results of the 1935 experiments have not yet become available and will not be definitely proven out until 1937.

Pine engraver beetles, (Ips spp.):

Ips confusus is a very common killer of the tops of mature trees and it occasionally kills groups of small trees of pole size. The infestation is sporadic, however, and the beetles may appear in great numbers one season and be almost entirely absent the next. The 1931-33 epidemic of the western pine beetle in this Park was preceded in 1930 and 1931 by a widespread top killing due to Ips. The engraver beetle, however, subsided in 1931, while the Dendroctonus infestation continued to gain momentum. In the Parks this

beetle attacks ponderosa pine, sugar pine, and Jeffrey pine.

Ips emarginatus is the largest species of the genus and is cosmopolitan in its tastes, attacking ponderosa pine, sugar pine, Jeffrey pine, and lodgepole pine. It is usually associated with other barkbeetles, and is almost always found with Dendroctonus jeffreyi in attacks on Jeffrey pine. It commonly occurs in association with the mountain pine beetle in lodgepole pine infestations.

Ips integer is also a common engraver beetle in the ponderosa pine and lodgepole pine stands of the Park. It is the most numerous of the engraver beetles in the lodgepole forests.

Control of the engraver beetles has not been attempted in the Park, except as occasional broods are destroyed when Dendroctonus projects are in progress. Measures to prevent their breeding up in slash from road clearings and other development work are desirable, as these beetles often emerge from slash to attack living trees. Such preventive measures, consisting of burning or peeling the bark on greenlogs, have been employed in nearly all road operations and other clearing projects in recent years.

Pine flathead borers, *Melanophila* spp.):

Occasionally trees growing on the poorer sites and dry exposures are killed by the pine flathead borers, *Melanophila californica* and *M. gentilis*. These insects are quite different in their habits from Dendroctonus and Ips. They feed on limbs as well as on the main bole, and as a rule, weakened, injured, and windblown trees are preferred. The trees are slowly killed by larval mines under the bark, the adults not extending galleries in the cambium but laying their eggs in the outer bark crevices.

Sugar pine, ponderosa pine, and Jeffrey pine are all subject to the attacks of the flathead borers. A common form of attack begins with the killing of the top by flatheads. The main bole is later infested by Dendroctonus. Flathead larvae may work in the living cambium of a tree for a number of years without killing it and, if growing conditions are favorable for the tree, it survives and heals over the scars of the larval mines. However, repeated attacks of the larvae usually weaken a tree so that it falls an easy victim to barkbeetles.

The flathead infestations which have developed in the pine areas of the Park cannot be considered epidemic or even threatening, and the losses directly attributable to them are a minor factor in all of the pine areas. Trees infested by flatheads have been treated wherever they have occurred on the barkbeetle control projects.

Fir engraver beetle:

Many of the white fir and red fir stands of the Park contain a disturbing number of dead topped, dying and dead trees. Most of this injury is caused by the fir engraver beetle, Scolytus ventralis Lec., an insect which breeds in the cambium layer of the bark in much the same manner as other barkbeetles. It differs, however, in its habits of attack, in that its attacks are not always concentrated on certain trees or groups of trees, but may be dispersed through a rather high percent of all trees in the stand. Patches of bark along the main bole may be attacked and broods develop successfully, but the tree survives, with injury evident only in dead and dying limbs. Killing of the upper 15 to 25 feet of the crown is a very common type of injury caused by this insect. Under certain conditions, however, the engraver beetle concentrates in numbers on certain trees and kills them outright in one season.

Considerable injury caused by Scolytus may be found throughout the fir type, but it cannot be said that any areas stand out conspicuously above others in the Yosemite. Methods of controlling the fir engraver beetle have not been successfully developed or demonstrated. Since the total population is widely distributed among many trees in the forest, and not concentrated in single trees and groups, the problem of control will be a difficult one to solve by the ordinary methods of cutting the trees and destroying the infested bark surface. To make an effective reduction of the infestation it will apparently be necessary to destroy the broods in many living trees, involving the sacrifice of trees which might survive. In roadside clearing and camp ground improvement operations, however, it is good practice to destroy the broods in infested trees where these can be selected for cutting and this practice has been followed to some extent in the Park.

Douglas fir flathead:

Since 1930, a heavy loss of Douglas fir has occurred in the Merced and Tuolumne Canyons. The insect considered responsible for this condition is the flathead borer, Melanophila drummondi. Its work and habits of attack are very similar to those of the pine flathead borer, but the infestation has recently shown much more aggressive tendencies than that of the species which attack the pines.

On the talus slopes surrounding the upper Yosemite Valley, hundreds of Douglas firs began dying in 1930; and in 1931 these red trees were conspicuous from all view points on the valley floor. This condition was most noticeable around Mirror Lake and extended down the Merced Canyon to the Park boundary. It is evident that if the infestation continues in its present tendencies, this most southern exhibit of Douglas firs in the Sierras is threatened with

extinction. The killing of Douglas fir is also conspicuous in the Hetch Hetchy Canyon.

Since 1933 control measures involving the cutting and burning of the infested trees have been carried on with CCC labor during the winter periods. Because of the inaccessible places in which many of the infested trees occur on the talus slopes and valley walls, it is practically impossible to accomplish a complete clean-up, but the work is gradually effecting some reduction in these losses.

Miscellaneous types of infestation:

Other problems considered to be of minor importance, have appeared from time to time and new ones may develop in the future. At least two introduced pests have made their appearance in the Park. One of these is the elm leaf beetle which has defoliated the planted elms on the Valley floor. The oyster-shell scale has been established for a considerable period and has caused rather severe injury to cottonwoods, willows, dogwood, and other deciduous trees and shrubs.

The dying of incense cedar in various parts of the Park in recent years has been noticeable, but little attention has been given either to the study of its cause, or to methods of control and prevention. Many mature cedars on the lower Yosemite Valley floor have died since 1930. The trouble is also prevalent in North Mountain region near the western boundary of the Park. So far as we know two insects are responsible for a large part of this damage. The more important is the roundhead borer, Semanotus amethystinus. The other is a small barkbeetle, Phloeosinus fulgens.

Insect Control Funds:

Adequate financing of control work is of paramount importance and is the first step in the organization of a control project. In the National Parks it is dependent upon specific allotment of funds which must be provided sufficiently in advance of the control period to allow completion of plans and full organization of the project. These funds are set up by the Director of the National Park Service upon special request of the Superintendent and are made available for this purpose alone.

However, considerable maintenance control work has been accomplished in this park by the CCC camps since their assignment in 1933. This work is financed independently of the regular Park activities and is not dependent upon specific allotments.

FOREST INSECT SURVEYS

In order to determine the extent and magnitude of insect depredations, it is necessary to make insect surveys of the suspected territory. The frequency of these surveys is determined by the character of the data to be obtained; that is, whether the amount of the annual loss only, or that of the more frequent seasonal losses is desired.

In the Yosemite, both annual and seasonal surveys are made. The work is done by the National Park Service foresters, with the help when necessary, of trained assistants. An annual survey is made of the entire Park, and, in areas where insects develop more than one generation a year, surveys are usually made more frequently. The lodgepole and Jeffrey pine stands occur at high altitudes where the season of insect activity is short and the insects develop only one brood a year. Annual surveys in these areas are sufficient to secure all the data required for control operations, or for ascertaining the trend of the infestations. This is true of those parts of the ponderosa-sugar pine stands which are remote from the recreational areas and where only annual control work is carried out. More frequent surveys, however, are necessary in areas of high recreational and aesthetic value, such as the campgrounds and road screens, the Valley floor, and the Mariposa Grove.

The methods used in making the Yosemite surveys are standard and of the same type used and recommended by the Bureau of Entomology. Briefly, they consist of the establishment of several sample plots of from 40 to 320 acres each, located throughout the forest, and typical of the general region. These plots are intensively examined and all insect infested trees are marked and tabulated. The data secured is applicable to the surrounding forest. To date, 5 permanent sample plots have been established in the ponderosa-sugar pine forests of the Park. Their location is indicated by the place names which usually are the local names of the infestation units in which they are situated. They are; Wawona, Black Rascal, Grouse Creek, Big Meadows and Ackerson Meadows.

In addition the Bureau of Entomology and Plant Quarantine maintains a permanent plot near the Aspen Valley entrance to the Park, which is surveyed each year.

The floor of the Yosemite Valley, while not a check area in the accepted sense, is cruised periodically during the seasons of greatest insect activity in order to locate and remove any infested trees. Because of the intensive use to which this Valley is subjected, a constant watch is maintained on all insect activity in its forests.

In addition to the annual cruises of the permanent plots, the Park personnel survey strips 10 chains wide through the ponderosa-sugar pine stands along the south and west boundaries of the Park. These sample strip cruises are made once a year in September for the purpose of estimating the amount of infestation present in the stands and the need for control work.

So far no permanent sample plots have been established in the lodgepole pine and Jeffrey pine stands of the upper park country, although these forests have been examined each year by more extensive survey methods. There is a real need for securing more intensive data on the annual trends of these infestations. This can be accomplished by setting up small permanent plots in Little Yosemite and Illilouette Basin, in the Jeffrey pine stands; and at Porcupine Flat and the Tuolumne Meadows, in the lodgepole pine stands. An annual survey of these plots, supplemented by the more extensive examinations of the surrounding forests, would be sufficient for all purposes.

Since the lodgepole pine needleminer has recently shown indications of an impending epidemic throughout the Tuolumne watershed the value of continued observations on its activity cannot be over-emphasized. A close watch may be kept on this insect by annual surveys of the lodgepole pine forests; particularly those in the stream basins north of the Tuolumne River and those surrounding the Tuolumne Meadows. The nuclei at Porcupine Flat and on the east flank of Clouds Rest are important centers to watch, as well as the lodgepole forests at Peregrine Meadows which are in line with a southward expansion of the present infestation.

LIST OF MAJOR INSECT CONTROL PROJECTS, - 1913-34,

SHOWING DATE, LOCATION AND NUMBER OF TREES TREATED.

The following summary of forest insect control work completed during this 22 year period has been compiled from reports on file at the Forest Insect Laboratory of the Bureau of Entomology and Plant Quarantine at Berkeley, California, and from reports and memoranda on file in the Superintendent's Office at Yosemite, California.

No attempt has been made in the following table to separate the data dealing with the tree species and the insect species in the separate control areas. For example, all the trees killed and the insects that killed them in any one year in the Wawona Basin have been lumped for convenience of tabulation, and also because the data at hand are not sufficiently explicit on these points to allow further segregation. No records were kept on the volume in board feet of the trees treated in control work prior to 1932, hence these data are lacking.

The following abbreviations for tree species and insect species have been used:

- L. pine signifies lodgepole pine
- J. pine signifies Jeffrey pine
- P. pine signifies ponderosa pine
- S. pine signifies sugar pine
- Df. signifies Douglas fir
- Dm. signifies the mountain pine beetle, Dendroctonus monticolae
- Db. signifies the western pine beetle, Dendroctonus brevicornis
- Dj. signifies the Jeffrey pine beetle, Dendroctonus jeffreyi
- Md. signifies the Douglas fir flathead, Melanophila drummndi

Year	Location of Areas	No. Trees Treated	Volume	Tree species and insect
1913	Tenaya Lake and Murphy Creek	249		L.pine, Dm
	Cathedral Creek and Magee Lake	1,335		L.pine, Dm
1914	Tenaya Lake and Murphy Creek	624		L. pine, Dm
	Cathedral Creek	281		L. pine, Dm
	Virginia Canyon	540		L. pine, Dm
	Smoky Jack Meadows (Alkali Creek)	317		L. pine, Dm
	Illilouette	151		J. pine, Dj
	Yosemite Valley	16		P. pine, Db
	Big Meadows	102		P.pine, S.pine, Db & Dm
1915	Illilouette	68		J.pine, Dj
	Little Yosemite	104		J.pine, P.pine, Dj & Dm
	Yosemite Valley	3		P.pine, S.pine, Db & Dm
	Wawona Road	56		P.pine, S.pine, Db & Dm
	Big Meadows	253		P. pine, S.pine, Db & Dm

Year	Location of Area	No. Trees Treated	Volume	Tree species and insect
1916	Tenaya Lake	108		L.pine, Dm
	Illilouette	65		J.pine, Dj
	Yosemite Valley	12		P.pine, Db
	Wawona Road	17		P.pine, S.pine, Db & Dm
	Big Meadows	36		P.pine, Db
1917	Tenaya Lake	230		L.pine, Dm
	Yosemite Valley	10		P.pine, Db
	Big Meadows	16		P.pine, Db
1918	Little Yosemite	25		J.pine, Dj & Dm
	Snow Creek	6		J.pine, Dj
	Yosemite Valley	13		P.pine, Db
	Wawona Road	15		P.pine, S.pine, Db & Dm
	Big Meadows	12		P.pine, S.pine, Db & Dm
1919	Yosemite Valley	9		P.pine, Db
1923	Yosemite Valley	9		P.pine, Db
	Wawona Road	43		P.pine, Db
	Wawona Basin	315		P.pine, S.pine, Db & Dm
	Big Meadows	169		P.pine, S.pine, Db & Dm
1932	Yosemite Valley	106	182,840	P.pine, S.pine, Db & Dm
	Wawona Road, Big Meadows & Big Oak Flat Road	565	572,700	J.pine, L.pine, P.pine, S.pine; Dj, Dm & Db
	Mariposa Grove	120	469,450	P.pine, S.pine, Db & Dm
	Mariposa Grove (Fall work)	158	896,180	P.pine, S.pine, Db & Dm
	Wawona Basin (Fall Work)	39	90,170	P.pine, S.pine, Db & Dm
1933	Yosemite Valley (includes walls)	301	464,040	P.pine, S.pine, Db & Dm
			4,248,190	P.pine, S.pine, J.pine,
	Wawona Basin and Wawona Dome	1,330	4,248,190	P.pine, S.pine, J.pine, Db, Dm, and Dj
	Wawona Road	727	2,618,640	P.pine, S.pine, Db & Dm
	Big Meadows and Crane Flat	539	1,151,520	P.pine, S.pine, Db & Dm
	Ackerson Meadow and South Fork	781	3,114,940	P.pine, S.pine, J.pine, Db, Dm, and Dj
	Vernal Falls	6	12,020	P.pine, S.pine, J.pine, Db, Dm and Dj
1934	Yosemite Valley	13	25,810	P.pine, Db
	Yosemite Valley	373	455,990	Df - Md
	Talus slopes, Wawona Basin and Wawona Road	484	1,083,780	P.pine, S.pine, Db & Dm
	Big Meadows and Crane Flat	527	1,368,130	P.pine, S.pine, Db & Dm
	Ackerson Meadows and South Fork	593	1,464,560	P.pine, S.pine, J.pine, Db, Dm and Dj
	El Portal Pocket	50	57,760	P.pine, Db
	Porcupine Flat	181	71,340	L.pine, Dm - Ips spp.
1935	Big Oak Flat Control	73	133,430	P.pine, S.pine, J.pine, Df, Db, Dm, Dj, Md

In addition to these primary control projects, insect control maintenance has become an established practice in the forests of the Yosemite. The purpose of this phase of control is to maintain a normal balance between insect activity and forest replacement, and to prevent the recurrence of the epidemic outbreaks which necessitate major control operations. This work is being accomplished through the CCC organization, and since 1933 it has become a regular feature of CCC activities. The maintenance operations employ all of the effective methods of control, including burning in place, burning in pits, burning in decks, use of solar heat, and of oil spray, and in certain areas the entire removal of the trees to burning dumps.

Maintenance control carried out by CCC camps during the four enrollment periods from 1933 to 1935 is listed in the following summary:

INSECT CONTROL MAINTENANCE BY CCC

First Enrollment Period - 1933

Location of Area	No. trees Treated	Volume	Tree Species and Insect
Wawona Basin-Marip.Gr.	129	643,620	P.pine, S.pine, J.pine, Db,Dm,Dj
Little Yosemite	207	261,670	P.pine, S.pine, J.pine, L.pine, Db, Dm, Dj, <u>Ips emarginatus</u>
Wawona Road-Alder Cr.	120	425,340	P.pine, S.pine, Db, and Dm
Wawona Road-Tunnel	105	396,380	P.pine, S.pine, J.pine, Db,Dm,Dj
Crane Flat	83	345,040	P.pine, S.pine, J.pine, Db,Dm,Dj

Second Enrollment Period - 1933-34

Tuolumne Grove and North Crane Creek	107	360,210	P.pine, S.pine, Db and Dm
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Third Enrollment Period - 1934

Wawona Basin-Marip.Gr.	234	740,100	P.pine, S.pine, J.pine, Db,Dm,Dj
Wawona Road-Chinquapin	171	660,020	P.pine, S.pine, J.pine, Db,Dm,Dj
Crane Flat - Gentry	89	390,220	P.pine, S.pine, J.pine, Db,Dm,Dj
Miguel Meadows	101	113,170	S.pine, J.pine, Dm,Dj, Flatheads
Tuolumne Meadows	236	80,180	L.pine, Dm, Ips
Yosemite Valley	111	24,100	P.pine, Db, Dm, Flatheads
Illilouette Canyon	188	336,820	S.pine, J.pine, L.pine,Dm,Dj,Ips

Fourth Enrollment Period - 1934-35

Miguel Meadows	110	292,050	P.pine, S.pine, J.pine, L.pine, Db, Dm, Dj, Flatheads
Wawona Basin-Marip.Gr.	263	643,370	P.pine, S.pine, Db, Dm
Yosemite Valley-Wawona	437	743,890	P.pine, S.pine, J.pine, Df, Db, Dm, Dj, Md

UNPUBLISHED REPORTS DEALING WITH THE FOREST INSECTS

OF THE YOSEMITE NATIONAL PARK

1911 - Meinecke, E. P.

Report of an examination made July 27-30, 1911, of lodgepole pine areas in the northeastern part of Yosemite National Park, including Tenaya, Tuolumne Meadows and Conness Creek, infested by a needleminer. (Report to Department of Interior)

1912 - Miller, J. M.

Reconnaissance of Tenaya and Tuolumne areas dealing with needleminer and mountain pine beetle. (Report to A. D. Hopkins, Bureau of Entomology, Oct. 9, 1912)

1913 - Hopkins, A. D.

Notes on forest insect depredations in the Yosemite National Park. (Paper presented at the Entomological Society of Washington, December 1913.)

1913 - Miller, J. M.

Needleminer and barkbeetle surveys, season of 1913. Report to A. D. Hopkins, Bureau of Entomology, November 25, 1913)

1913 - Sullivan, J. J.

Tenaya and Cathedral mountain pine beetle control projects, season of 1913. (Report to Bureau of Entomology, November 23, 1913)

1914 - Miller, J. M.

Biological notes on the needleminer, Recurvaria milleri, Busck., and the mountain pine beetle, Dendroctonus monticolae, Hopk., (Report to Bureau of Entomology, January 22, 1914)

1915 - Sullivan, J. J.

Demonstration work in insect control and reconnaissance of insect infestations in Yosemite National Park, season of 1915. (Report to Bureau of Entomology, December 23, 1915)

1916 - Hopkins, A. D.

Review of instructions and demonstration control work from July 1913, to September 1915, with recommendations for 1916. (Memorandum for Mr. Stephen T. Mather, Assistant to the Secretary of the Interior Department)

- 1916 - Miller, J. M.
Forest Insect conditions 1916 and summary of control work 1913-16. (Report to Bureau of Entomology, September 28, 1916)
- 1916 - Adair, C. F.
Memorandum to W. B. Lewis, Supervisor, Yosemite National Park, reporting upon surveys and control work during 1916.
- 1917 - Miller, J. M.
Insect infestations in the Yosemite National Park, season of 1917 and recommendations for 1918. (Memorandum to A. D. Hopkins, December 1917)
- 1917 - Miller, J. M.
Proposed control measures, Yosemite National Park, Survey of 1917. (Report to A. D. Hopkins, Bureau of Entomology)
- 1917 - Glendenning, W. E.
Forest insect reconnaissance of yellow pine and sugar pine areas in Yosemite National Park, May and June 1917. (Section of 1917 California Insect Survey Report submitted to Yosemite National Park)
- 1917 - Patterson, J. E.
Field notes of examinations of July 29 to September 18, 1917, mainly in the needleminer areas. (Memorandum to J. M. Miller)
- 1917 - Patterson, J. E.
Status of the 1917 Dendroctonus infestations in the Yosemite National Park. (Report to Bureau of Entomology, November 27, 1917)
- 1917 - Patterson, J. E.
An account of the attack and mating habits of Dendroctonus monticolae, Hopk. (Memorandum to A. D. Hopkins, November 28, 1917)
- 1917 - Patterson, J. E.
Notes on the overwintered broods of Dendroctonus monticolae Hopk. in lodgepole pine, Yosemite National Park. (Memorandum to A. D. Hopkins)
- 1918 - Patterson, J. E.
Forest insect control Yosemite National Park, season of 1918. (Report to Bureau of Entomology, January 11, 1919)

- 1918 - Patterson, J. E.
Treatment of infestation and proposed future work on the Yosemite Valley Floor, Snow Creek Basin, and Crane Creek Basin, season of 1918. (Report to Bureau of Entomology, April 11, 1919.)
- 1918 - Patterson, J. E.
Seasonal history studies of *Dendroctonus* beetles, season of 1918. (Report to Bureau of Entomology, April 11, 1919.)
- 1918 - Patterson, J. E.
Reconnaissance of needleminer areas in the Yosemite National Park, season of 1918. (Memorandum of field notes, Bureau of Entomology.)
- 1919 - Patterson, J. E.
Survey of distribution of lodgepole needleminer in the Tuolumne and Merced River basins, August 18 to 27, 1919. (Report to Bureau of Entomology, October 1919.)
- 1919 - Patterson, J. E.
Seasonal history studies and surveys, seasons of 1918-1919. Yosemite National Park. (Report to A. D. Hopkins, Bureau of Entomology.)
- 1919 - Patterson, J. E.
Dendroctonus brevicomis, Lec., *Dendroctonus monticolae*, Hopk., and *Dendroctonus jeffreyi*, Hopk., in the Yosemite National Park. (Report to A. D. Hopkins, Bureau of Entomology.)
- 1919 - Patterson, J. E.
Insect infestations and control work, season of 1919 Yosemite National Park. (Report to Bureau of Entomology)
- 1923 - Patterson, J. E.
Memorandum of examination made of forest insect conditions in Yosemite National Park, season of 1923. (Report to Bureau of Entomology, August 9, 1923.)
- 1923 - Patterson, J. E.
History and review of Yosemite National Park control projects, season of 1918 and 1919. (Report to Bureau of Entomology, January 19, 1923.)
- 1924 - Miller, J. M.
Forest insect conditions Yosemite National Park, season of 1924. (Report to Bureau of Entomology, September 1924.)

- 1925 - Miller, J. M.
Forest insect conditions noted July 20 to August 1, 1925. (Memorandum to Superintendent W. B. Lewis, August 24, 1925.)
- 1929 - Burke, H. E. and Edmonston, W. D.
Forest insect conditions in and around Yosemite National Park, season of 1928. (Report to Bureau of Entomology, January 30, 1929)
- 1929 - Miller, J. M. and Burke, H. E.
Forest insect conditions on the Valley floor and plans for insect control for year 1930. (Report to Bureau of Entomology, August 31, 1929.)
- 1930 - Salman, K. A.
Plans for insect control for year 1931. Yosemite National Park. (Memorandum for Superintendent, September 11, 1930.)
- 1930 - Miller, J. M.
Plans for insect control, Yosemite National Park, Fiscal year 1930. (Report to Superintendent, Yosemite National Park.)
- 1931 - Thomson, C. G.
Insect control work Yosemite National Park, spring of 1931. (National Park Service Report, June 11, 1931.)
- 1931 - Baumhofer, L. G.
Yosemite National Park barkbeetle control project, 1931. (Report to J. M. Miller, Bureau of Entomology.)
- 1931 - Salman, K. A.
Insect conditions, Yosemite National Park, supplementary memorandum. (Report to Bureau of Entomology, March 1931.)
- 1931 - Salman, K. A.
Insect conditions, Yosemite National Park. (Report to Bureau of Entomology, 1931.)
- 1932 - Salman, K. A.
Suggestions for insect control survey, remainder of 1932 season, Yosemite National Park, (Report to Superintendent, July 1932.)
- 1932 - Ernst, Emil
Forest insect surveys for 1932, Yosemite National Park. (National Park Service report, September 1, 1932.)

- 1932 - Miller, J. M.
Proposed plans for forest insect survey, Yosemite National Park. (Report to Superintendent Yosemite National Park, 1932.)
- 1932 - Merrill, W. K.
Report on insect conditions and recommendations for spring of 1932. (Report to National Park Service, October 1931.)
- 1932 - Thomson, C. G.
Annual report Yosemite National Park, 1932. (Report to the National Park Service.)
- 1932 - Ernst, Emil
Report on forest insect surveys for 1932, Yosemite National Park. (Report to the National Park Service, September 1932.)
- 1932 - Ernst, Emil
Forest insect progress report for 1932, and the present situation. (Report to National Park Service, September 1932.)
- 1933 - Miller, J. M.
Douglas fir infestations and spring control program, Yosemite National Park. (Memorandum for Superintendent, Yosemite National Park, January 4, 1933.)
- 1933 - Ernst, Emil
Insect control projects spring of 1933. (National Park Service report, July 8, 1933.)
- 1933 - Ernst, Emil
Various monthly progress reports to Park Superintendent
- 1934 - Ernst, Emil
Insect control projects spring of 1934. (National Park Service report, July 1934.)
- 1934 - Ernst, Emil
Various monthly progress reports to Park Superintendent
- 1934 - Salman, K. A.
Preliminary tests of sprays for control of the lodgepole needleminer. (Report to Park Superintendent January 1934.)
- 1934 - Salman, K. A.
Further results of sprays for control of the lodgepole pine needleminer. (Memorandum to Park Superintendent, September 10, 1934.)

1934 - DeLeon, Donald

Annual forest insect control report for the National Parks, season of 1933. (Report to National Park Service January 8, 1934.)

1935 - Ernst, Emil

Various monthly progress reports to Park Superintendent

PUBLICATIONS ON FOREST INSECTS OF YOSEMITE NATIONAL PARK

Burke, H. E. -

1928 - Forest Insect Infestations in the National Parks. (Yosemite - part). Yearbook, Department of Agriculture, Washington, D. C.

DeLeon, Donald -

1935 - Forest Insects of the California National Parks, Part I. (Yosemite - part, Mimeographed manual). Berkeley, California

Hopkins, A. D. -

1909 - Barkbeetles of the Genus *Dendroctonus*. (Yosemite - part). U. S. Department of Agriculture Bureau of Entomology Bulletin No. 83, Part I. Washington, D. C.

Patterson, J. E. -

1921 - Life History of *Recurvaria milleri*, the Lodgepole Pine Needleminer in the Yosemite National Park, California. Journal of Agricultural Research, Vol. XXL, No. 3, p 127-142, May 2, 1921. Washington, D. C.

Patterson, J. E. -

1929 - Forest Insects of Yosemite National Park. (Mimeographed manual). April 1929. Stanford University, California.

Van Dyke, Edwin C. -

1921 - Insects of Yosemite National Park. (In Hall, Ansel F. - Handbook of Yosemite National Park. p. 205-218.) G. P. Putnam's Sons, New York, 1921.